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Training Use Distribution Modeling

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Introduction

This technical note provides an overview of the objectives, scope, and development of the maneuver impacts distribution model being developed as part of the Land Based Carrying Capacity (LBCC) effort. It includes a brief description of the development process, an example of its current functional status, and discussion of future efforts.

Background

Scientists from the U.S. Army Construction Engineering Laboratories (USACERL) along with many university partners have been studying ways to predict the impacts of land-based military training since the early 1980s. Balbach and Coin (1984) proposed a conceptual model for quantifying land use demands based on vehicle category. Warren and others (1989) integrated the Universal Soil Loss Equation (USLE) with a geographic information system to assist in planning military training activities to reduce environmental impacts. Diersing and others (1989) built upon this system and created the Tracked Vehicle Day (TVD) approach to carrying capacity. The TVD approach characterized maneuver training areas (MTAs) by the level of vehicle use that could be sustained before erosion rates exceeded acceptable levels.

Since these early efforts, two new efforts have been undertaken. The first effort is a model based on production and successional dynamics of plant communities in MTAs (McLendon, Childress, and Price 1996; Childress, McLendon, and Price 1996). This ecological model is the focal point of USACERL's LBCC initiative. The second effort is the result of the "Evaluation of Land Values Study" (ELVS) conducted by the U.S. Army Concepts Analysis Agency (U.S. Army CAA 1996). This model was designed to be integrated into the Army's operation tempo models to predict repair and maintenance costs. Since the completion of ELVS, it has evolved into the current Army Training and Testing Areas Carrying Capacity program (ATTACC) (Anderson et. al. 1996). Both the successional model and the ELVS study results incorporate information on training distribution on training lands.

Modeling Objective and Scope

The objective of the effort to model maneuver distribution impacts is to develop the capability to predict the spatial distribution and intensity of off-road maneuver training miles. The scope focuses on developing protocols and statistical models to be incorporated into a software model that will interface with various efforts in ecological carrying capacity and provide disturbance data for those models. The initial focus of the modeling effort was to use simple techniques and incorporate existing data so that the model can be quickly adapted to the wide range of Army installations.

Approach

The overall approach is to develop a software model that will produce both spatial and tabular representations of future maneuver disturbances. Model development is based on the following framework:

I. User Interface
  • capable of accepting both human and automated inputs.

II. Disturbance Map
  • primary mechanism for use allocation within training areas.

III. Event Schedule Database
  • complete listing of training events and relevant attributes.

IV. Event Placement Submodel
  • allocates training events over time across training areas.

V. Intensity Calculation Submodel
  • converts event information at the sub-MTA level into multiple pass results.

VI. Output Mechanism
  • translates model outputs into both spatial and tabular outputs for human and computer model use.

Each component of this framework is represented in the computer model as either a series of mathematical equations (e.g., submodel), an information database, or the user interface.

The primary components of the working model are the Disturbance Map (II), and an Event Schedule Database (III). These two components contain installation-specific data and form the basis for future disturbance calculations. The Disturbance Map predicts the probability of any particular area of maneuver training land being impacted by vehicle traffic over the course of a year. The map is calibrated using nonlinear regression statistics. Land Condition Trend Analysis disturbance data (Tazik et. al. 1992) is used as the dependant variable. Independent variables vary according to installation, but include slope, distance to maintained roads, vegetation cover, training area type, and other spatial features that have an influence on where training occurs (Dubois 1994, Krzysik 1994). The calibrated map represents an extrapolation of past disturbance across the landscape. Given the following assumptions: (1) no major changes in training doctrine, (2) no major changes in MTA infrastructure, and (3) no major changes in unit stationing, future use should follow the same general patterns.

The Event Schedule Database (III) contains a detailed listing of training events that may occur at a particular installation. It consists of a comprehensive list of training exercises and includes information such as unit type and size, number and types of vehicles, off-road miles, and average track width. Event descriptions and associated information are the same as those of the ELVS/ATTACC methodology (U.S. Army CAA 1996, Anderson et. al. 1996).

Information from the event database and disturbance map are converted into future disturbance predictions via the Event Placement Submodel (IV) and the Intensity Calculation Submodel (V). Individual training events are placed in appropriate training areas by a model that is calibrated with historical use data and information from relevant installation regulations (e.g., III Corps and Fort Hood Regulation 350-40). Once placed in the proper training area, mileage data from these events are converted into number of passes per map cell and the proportion of multiple passes are calculated based on a binomial distribution (i.e., tracked vs. untracked land area).

Data inputs and outputs for the model (Parts I and VI) are handled through an interface that accepts user commands or interfaces with another computer model (e.g., ecological succession model). Initially, output information is at the monthly scale which coincides with the vegetation module of the ecological succession model (McLendon, Childress, and Price 1996). The time scale can be modified to meet the requirements of other carrying capacity models.

Current Development

This effort started at the beginning of fiscal year (FY) 1996. Due to the large amount of interest in environmental/simulation modeling at Fort Hood, Texas (Price et. al. 1997, U.S. Army CAA 1996, Anderson et. al. 1996) this installation was chosen as the focus of initial model development. By the end of FY 96, a prototype had been completed which covered a limited area of Fort Hood.

This prototype has some form of all seven framework components described above, including a disturbance map calibrated for Fort Hood (Figure 1). The approximate significance for calibration variables used in the statistical model for the development this map was $P < 0.05$. In the summer of 1996, 41 validation plots were established in training areas 35 and 41. Data from these plots showed that the extrapolation of disturbance was underestimated by 5 percent.

Training events are represented using data at the individual vehicle and day scale, however results are produced to represent cumulative impacts over a time frame of a month or longer. Currently spatial scale is 50- by 50-meter cells with output maps representing average tracking (pass) densities per cell and maps depicting percent of cell tracked at given rates (i.e., 1 to 5 passes per square meter). The current model is capable of predicting maneuver patterns on an individual training area basis (Figures 2 and 3). A model covering all of Fort Hood's training land is planned for completion by the end of FY 97.

Future Development

Plans for continuing development of the training disturbance model includes:

- completion of a Fort Hood model by the end of FY 97,
- continued validation of current model components,
- development of an automated disturbance mapping tool, and
- expanded modeling efforts to cover additional installations.

Currently the disturbance model is functional for a limited number of MTAs at Fort Hood. By September 1997 plans are to have a model that will represent all MTAs at the installation. Additionally, the model currently represents only tracked and wheeled vehicle disturbance. Initial efforts are underway to expand the training activities represented in the model. The expanded activities include artillery and impact zones, and foot traffic.

In the summer of 1996, a limited validation of the disturbance map was conducted. Future efforts will focus on validating the disturbance map for the entire installation and improving model components based on these validations. New sources of data, including individual vehicle tracking data, are being investigated. These data will be incorporated if they prove to increase the realism of model results.

To date, the input disturbance map for the model is calibrated on an installation basis and remains static throughout the running of the model. Future plans include the development of a tool to automate map calibration. This will allow for a more rapid transition of the model to other installations. Additionally, when the disturbance model is linked to the ecological succession model (McLendon, Childress, and Price 1996; Childress, McLendon, and Price 1996) and other carrying capacity models, feed-back from these models will allow for the disturbance map to change when the condition of training lands change.

The ELVS/ATTACC (U.S. Army CAA 1996, Anderson et. al. 1996) studies and the development of the ecological succession model are focused on multiple installations, including Fort Hood and Fort Bliss, TX; Fort Carson, CO; and Yakima Training Center, WA. To provide maximum value to these efforts, development of models for installations currently under consideration by these efforts will begin in FY 98. Other installations will be considered as funding and time permit.

Summary

USACERL's Training Use Distribution Modeling work unit began in FY 96. The effort's primary goal is to provide for a missing piece of current carrying capacity research—representing training as a nonuniform disturbance regime on the landscape. The work unit has already benefited the ELVS study (U.S. Army CAA 1996) and will continue to provide benefits as it addresses the needs of ATTACC and other carrying capacity efforts (Anderson et. al. 1996, Price et. al. 1997). Current accomplishments include a completed prototype for Fort Hood with a full-scale model planned for completion by the end of

FY 97. An initial validation of model components has produced acceptable results. Validations will continue as the modeling process progresses and the results will be incorporated to improve the model's performance. Future development will expand the Fort Hood efforts and cover additional installations involved in carrying capacity research.

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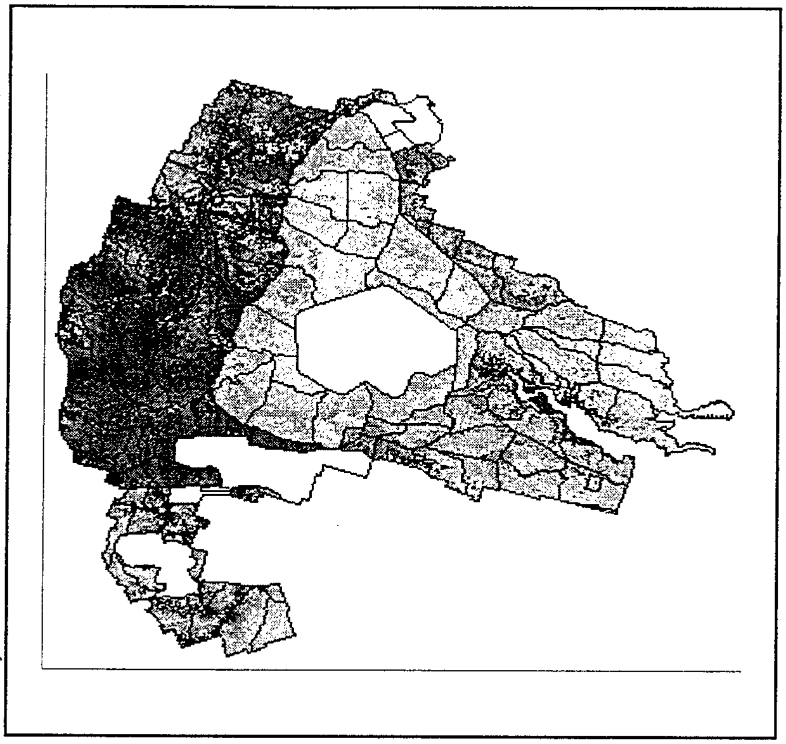

Figure 1. Fort Hood Impact Distribution Map (intensity ranges from light to dark).

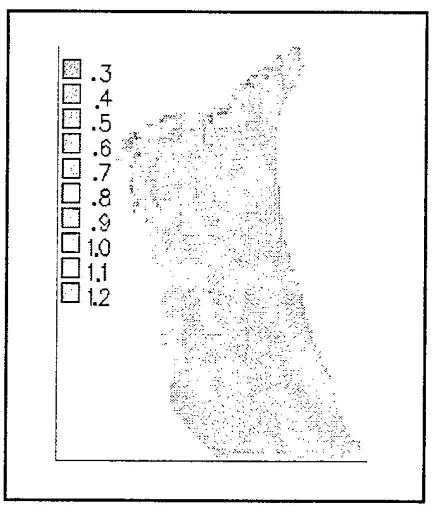

Figure 2. MTA 35b after 2,000 miles of maneuver training (average pass density per cell).

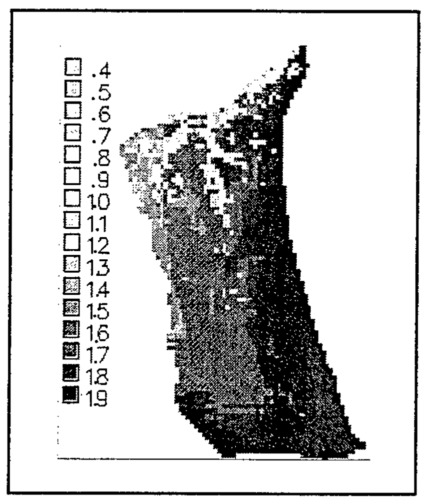

Figure 3. MTA 35b after 3,000 miles of maneuver training (average pass density per cell).